

526,890

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
18 March 2004 (18.03.2004)

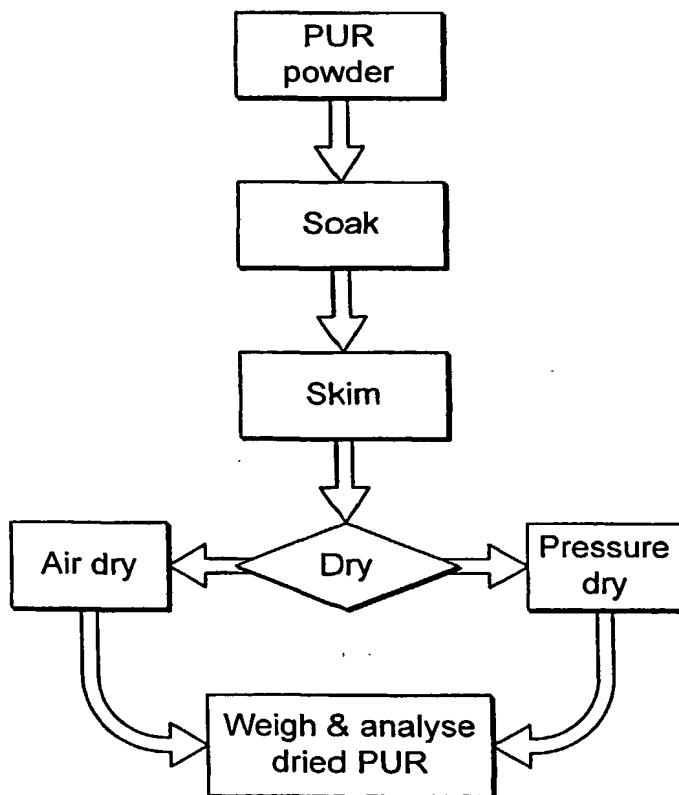
PCT

(10) International Publication Number
WO 2004/022503 A1

- (51) International Patent Classification⁷: **C04B 16/08**,
B28B 23/00, C08J 9/22
- (21) International Application Number:
PCT/GB2003/003844
- (22) International Filing Date:
4 September 2003 (04.09.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
0220510.2 4 September 2002 (04.09.2002) GB
- (71) Applicant (for all designated States except US): **PUR-
CRETE LIMITED** [GB/GB]; Baring House, 6 Baring
Crescent, Exeter, Devon EX1 1TL (GB).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **O'KANE, Kevin,
John** [GB/GB]; 27 Felton Street, Felton, Bristol BS40
9YL (GB).
- (74) Agents: **DEAN, John, Paul et al.**; Withers & Rogers,
Goldings House, 2 Hays Lane, London SE1 2HW (GB).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC,
SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA,
UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:
— with international search report

[Continued on next page]

(54) Title: POLYURETHANE-CONTAINING BUILDING MATERIALS



(57) Abstract: Concrete containing polyurethane is provided and construction elements comprising such concrete. Methods for the preparation of polyurethane for inclusion in such concrete and for the formation of construction elements comprising such concrete are also provided.

WO 2004/022503 A1

BEST AVAILABLE COPY



— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Polyurethane-containing building materials

Technical Field

This invention relates to building materials, particularly concretes containing polyurethane, and panels comprising such building materials. The invention also relates to methods for preparing such building materials.

Background Art

Panel boards are frequently used during the construction of buildings to form the surface of walls, floors and ceilings. Such panels generally comprise a core material sandwiched between two layers of covering material. Plasterboard is a commonly used example of a panel board, comprising hardened plaster sandwiched between two layers of card. Panel boards may also have plywood cores. In parts of a building which come into contact with water, for example bathrooms, panel boards may be used which could typically comprise gypsum-based plasterboard or a cement-based board sandwiched between two layers of mesh.

Several manufacturers have developed the construction of these basic panel board products using materials other than concrete to make them more lightweight than boards of traditional construction. For example, US-A-0082365 discloses a lightweight board comprising a polyisocyanurate or polyurethane foam core with lower and upper surfaces and filler material such as wood chips within the foam core. The board is intended primarily for use as an insulator in roof construction.

Marmox® (Marmox (UK) Ltd, Rochester, Kent, UK) is a lightweight unfinished board product which comprises extruded polystyrene with a fibreglass reinforced face set in a cement polymer adhesive. It is sufficiently strong to be suitable for the construction of walls and floors. The surface will accept both plaster and paint, or tiles to provide a finished surface. Marmox boards are also waterproof and therefore suitable for use in moist areas such as bathrooms.

Other panels include Aquapanel® which is a building board composed of cement and reinforced with glass fibre mesh. Respatex® and Wetwall™ are both board products comprising a plywood core and laminate faces, suitable for wall cladding only.

Polyurethane (PUR) is an artificial material which is used in rubber form, in sealants and in a rigid foam form as insulation for, amongst other things, refrigeration units. The blowing agents used to generate the foam structure in PUR foam have traditionally been chlorofluorocarbons (CFCs). The environmental consequences of the release of CFCs when a refrigeration unit is broken up at the end of its life are well known. Less widely publicised, however, are the consequences of the disposal of the remaining PUR foam waste, which often ends up in landfill sites. It is preferable to recycle such waste in order to minimise the volume of such material which ends up in landfills.

Disclosure of Invention

According to a first aspect of the invention there is provided concrete comprising PUR. The concrete may comprise a binding agent, water and PUR. The PUR may preferably be PUR foam. The binding agent may be cement or gypsum. Examples of suitable cement include, but are not restricted to, Ordinary Portland Cement, Rapid Hardening Portland Cement, Sulphate Resisting Portland Cement and other Portland Cements containing various additives. Examples of suitable gypsum-based products include, but are not restricted to, Gyproc®, Gyplite® and Blue Hawk®. In a preferred embodiment, the concrete may further comprise at least one bulking agent, waterproofing agent and/or flowing agent. The bulking agent may be limestone dust or silica sand. The waterproofing agent may be Xypex® admix C-1000 (Xypex Chemical Corporation, Canada) or Hydrophobe™ (WR Grace & Co., Cambridge, United Kingdom). The flowing agent may be an air entrainer, for example, Airalon™ (WR Grace & Co.).

Preferably, the concrete according to the invention may comprise:

Cement	240-450kg/m ³
PUR	200-395kg/m ³
Bulking agent	0-300kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	160-450 l/m ³

Most preferably the concrete according to the invention may comprise:

Cement	approx. 375kg/m ³
PUR	approx. 250kg/m ³
Bulking agent	approx. 250kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	approx. 200 l/m ³

Alternatively, the concrete according to the invention may comprise:

Cement	approx. 300kg/m ³
PUR	approx. 327kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	approx. 373 l/m ³

There is further provided a panel board comprising concrete according to the first aspect of the invention.

It is an advantage of the current invention that, as the result of the replacement of at least some of the usual sand bulking agent with PUR foam, the resultant concrete may be used to form panel boards which are lightweight compared with traditional concrete panel boards. The PUR-containing concrete panel boards are strong enough to be used in the construction of walls and floors and also can be waterproof such that they can be used to form walls in moist areas such as bathrooms.

According to a second aspect of the invention, there is provided a method for preparing dried expanded PUR foam for use in the preparation of concrete, comprising:

- a) soaking granulated PUR foam in water for a period of time sufficient to allow the PUR to expand;
- b) separating the PUR from the water; and
- c) drying the PUR.

It is a further advantage of this aspect of the current invention that the granulated PUR foam is pre-expanded by the soaking treatment, hence allowing it to stabilise, eliminating the risk of further expansion on addition of the remaining water and cement during mixing of PUR-containing concrete.

The water may be between pH 6 and pH 9. Preferably the water may be potable. The granulated PUR foam may be soaked in water for between about ten minutes and about two days, preferably for between about 1.5 and about 2.5 hours, most preferably for about 2 hours. The expanded PUR may be dried by standing in air or by forcing air past it. The air may be heated. The expanded PUR may be dried under pressure.

The method according to the second aspect of the invention may further comprise a step to determine the water content of the dried expanded PUR.

The granulated PUR foam used in the invention may comprise recycled PUR foam. The granulated PUR foam may be previously prepared from PUR foam chunks also containing impurities such as aluminium and/or plastics material. The PUR foam chunks may be granulated using a granulator, using high pressure water jets pressurised at between 10.35 and 48.25 MPa, preferably 20.7 MPa, or by adding water and mixing in a high shear mixer. The mixer may preferably operate at between 2000 and 6000 rpm, most preferably at about 4000 rpm. The impurities may be removed by passing the granulated PUR through a mesh screen, preferably of between 75 μm and 4750 μm gauge, most preferably of about 2360 μm gauge.

There is further provided dried expanded PUR obtainable by a method according to the second aspect of the invention.

There is also provided a method for preparing a building material which comprises mixing a binding agent, water and dried expanded PUR obtainable by a method according to the second aspect of the invention, and building materials so produced. The components of the building material may be mixed in a high shear mixer. The binding agent may be cement or gypsum. The method may further comprise mixing at least one bulking agent, waterproofing agent and/or flowing agent with the other components of the mix. The bulking agent may be limestone dust or silica sand. The waterproofing agent may be Xypex admix C-1000. The flowing agent may be an air entrainer or a plasticiser. The components of the mix may be present in the quantities:

Cement	240-450 kg/m ³
PUR	200-395 kg/m ³
Bulking agent	0-300 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	160-450 l/m ³

The components of the mix may preferably be present in the quantities:

Cement	approx. 375 kg/m ³
PUR	approx. 250 kg/m ³
Bulking agent	approx. 250 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	approx. 200 l/m ³

Alternatively, the components of the mix may be present in the quantities:

Cement	approx. 300 kg/m ³
PUR	approx. 327 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	approx. 373 l/m ³

According to a further aspect of the invention, there is provided a method of preparing a construction element comprising:

- a) preparing a mould sized to reflect the intended dimensions of the construction element;
- b) introducing a PUR building material comprising dried expanded PUR obtainable by a method according to the second aspect of the invention into the mould;
- c) curing the so formed construction element; and
- d) separating the mould and construction element.

Typically the construction element will be a panel board. Other construction elements include for example beams, spars and joists.

Preparing the mould may comprise laying glass fibre matting in the base of the mould and covering the matting with a layer of cementitious grout. The glass fibre matting may preferably be alkaline resistant. The cementitious grout layer may be 1-4 mm thick, preferably 1.5-2 mm thick, most preferably about 2 mm thick. The cementitious grout may have a plastic density of between 2000 and 2300 kg/m², preferably about 2180 kg/m² and have a cement content of between 400 and 500 kg/m³. The glass fibre matting may extend outside the mould. Following the pouring of the PUR building material into the mould, the glass fibre matting which extends outside the mould may be folded onto the non-mould facing surface of the PUR building material.

Preparing the mould may alternatively comprise spraying and rolling a layer of glass reinforced cement (GRC) into the base of the mould. The sprayed and rolled layer of GRC may be 1-4 mm thick, preferably 1.5-2 mm thick, most preferably about 2 mm thick. Glass fibre may be present in the GRC at about 2% w/w cementitious grout. Cementitious grout present in the GRC may have a plastic density of between 2000 and 2300 kg /m², preferably about 2180 kg/m² and a cement content of between 400 and 500 kg/m³. The GRC may be sprayed and rolled onto at least one extended mould piece and left for a period of time sufficient to allow the mix to set to form at least one GRC layer. Following the pouring of the PUR building material into the mould, the or each GRC layer may be folded onto the non-mould facing surface of the PUR building material.

After the PUR building material has been poured into the mould, the mould may be agitated to ensure uniform distribution within the mould of the PUR building material. The mould may be placed on a vibrating table to enable the agitation.

The method of preparing a construction element may further comprise:

- a) the laying of the glass fibre matting over the non-mould facing surface of the poured PUR building material; and
- b) the addition of a layer of cementitious grout over the top surface of the GRC matting.

The method may yet further comprise the trowel finishing of the cementitious grout layer. The glass fibre matting may preferably be alkaline resistant. The cementitious grout layer may be 1.5-2 mm thick. The cementitious grout may have a plastic density of between 2000 and 2300 kg/m², preferably about 2180 kg/m² and a cement content of between 400 and 500 kg/m³.

The method of preparing a construction element may alternatively further comprise the spraying and rolling of a layer of GRC onto the non-mould facing surface of the poured PUR building material. The method may yet further comprise the trowel finishing of the GRC layer. The sprayed and rolled layer of GRC may be 1.5-2 mm thick. Glass fibre may be present in the GRC at about 2% w/w cement grout. Cementitious grout present in the GRC may have a plastic density of between 2000 and 2300 kg/m², preferably about 2180 kg/m² and a cement content of between 400 and 500 kg/m³. The curing in the method of preparing a construction element may be air-curing for between 10 and 24 hours, preferably about 12 hours. Alternatively, the curing may be accelerated by curing in a mist chamber for between 6 and 15 hours, preferably about 8 hours.

There is further provided a construction element for use in construction obtainable by a method according to the invention.

There is further provided a building element comprising at least two construction elements which comprise dried expanded PUR obtainable by a method according to the second aspect of the invention. Typically, each construction element will be a panel board. The construction elements may be fixed together to maintain a void between each construction element. One or more voids may be filled with self compacting concrete, preferably reinforced concrete. One or more voids may be filled with air entrained concrete. The air entrained concrete may comprise PUR.

Brief Description of Drawings

Embodiments of the invention will now be described by way of example only and with reference to the following Figures 1-8 in which:

Figure 1 is a flow diagram showing the stages in a method of producing granulated PUR foam from recycled PUR foam briquettes;

Figure 2 is a flow diagram showing the stages in a method of producing dried expanded PUR;

Figure 3 shows a mould with glass fibre matting laid in the base and overlaid with a layer of cementitious grout;

Figure 4 is a cross-section along the line A-A;

Figure 5 shows a mould comprising extended mould pieces, with glass reinforced cement sprayed and rolled into the mould and onto the side extensions;

Figure 6 shows a cross-section along the line B-B;

Figure 7 is a flow diagram showing the stages in a method of producing a panel board constructed from PUR-containing building material; and

Figure 8 is a cross-section through a two-void building element constructed using PUR-containing panel boards.

Modes of Carrying Out the Invention

1. Preparing granulated PUR foam from PUR foam briquettes

PUR foam briquettes are produced when, for example, refrigeration units containing PUR foam are dismantled. The briquettes are formed from recycled PUR foam and contain impurities, for example, plastic and aluminium fragments. A method for converting PUR briquettes into PUR suitable for use in the methods and materials according to the invention is outlined in Figure 1.

The briquettes may first be broken down into granules using a granulator, such as a Getecha model RS3009 (Getecha UK Ltd, Warminster, Wiltshire, United Kingdom). Alternatively, they may be granulated using high pressure water jets, operating at a preferred pressure of 20.7 MPa. In a further alternative, the briquettes may be granulated by mixing with water and shredding in a high shear mixer, for example a GRC125 (2-speed) mixer (Power Sprays Ltd, Bristol, United Kingdom), typically operating at 4000 rpm.

The PUR granules, dry or wet depending on the method of granulation, are then passed through a screen, typically about 2360 μm gauge. This screen removes impurities such as pieces of plastic or aluminium, allowing cleaned granulated PUR to pass through.

2. Preparation of PUR for use in building materials.

Cleaned PUR prepared as described in Example 1 above or by other preparation means, or alternatively newly manufactured PUR foam, is prepared for use in building materials by a method which is summarised in Figure 2. The granulated PUR foam is soaked in potable water for about 2 hours. This period of time allows the PUR to fully expand to form expanded PUR which will typically float to the surface of the water.

The expanded PUR is skimmed from the surface of the water. It is then dried, either by air drying or by drying under pressure. The expanded PUR may be air dried by leaving it to stand in air, or by passing air over it. The air may be heated or be at ambient temperature. Alternatively, the expanded PUR may be pressure dried by squeezing the PUR and draining the water away.

The dried expanded PUR is then weighed and analysed for remaining water content. This allows the calculation of the correct volume of water to be added when the dried expanded PUR is used in the mixing of building materials. This weighing and analysing step may be omitted once a typical water content, resulting from a given set of preparation conditions, is known.

3. Mixing of building materials containing dried expanded PUR

Building materials containing dried expanded PUR may be cement based or gypsum based. Typical quantities of the components of such building materials are shown below, in Table 1:

Finished relative density	0.97	0.6
Cement	375 kg/m ³	300 kg/m ³
PUR	250 kg/m ³	327 kg/m ³
Limestone dust/silica sand	250 kg/m ³	0
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement	0.03-0.06% w/w cement
Water	200 l/m ³	373 l/m ³

Table 1- quantities of components of PUR-containing building material

The components of such building materials are mixed in a high-shear mixer, for example a GRC125 (2-speed) mixer as mentioned in Example 1 above.

4. Preparation of a mould for the production of PUR-containing panel boards

A mould, sized to reflect the finished board dimensions, is prepared in one of the two following ways:

- a) As shown in Figures 3 and 4, a sheet of alkaline-resistant glass fibre matting (1) is laid in a mould (5), extending outside the mould on two opposite sides (10, 15) by approximately 70-100mm. The matting lining the base (20) and sides (25, 30) of the mould is covered with an approximately 2 mm layer of cementitious grout (35), typically of plastic density of about 2180 kg/m³ and cement content of between 400 and 500 kg/m³.

- b) As shown in Figures 5 and 6, a mould (37) has extended mould pieces (40, 45) on two opposite sides (50, 55). A layer of glass-reinforced cement (GRC, glass fibre pre-mixed with cementitious grout) (60) is sprayed and rolled into the mould, also spraying the upper surfaces of the extended mould pieces with GRC up to 70-100mm from the sides of the mould (50, 55). The glass fibre is typically present at about 2% w/w cementitious grout. The cementitious grout typically is of plastic density of about 2180 kg/m³ and cement content of between 400 and 500 kg/m³.

The moulds may be prepared on a vibrating table.

5. Preparation of PUR-containing panel boards in prepared moulds.

The preparation of PUR-containing panel boards is outlined in Figure 7. A cement-based PUR-containing building material, of a composition described in Example 3 above, is introduced into a mould prepared as described in Example 4 above. The mould is then agitated to settle the PUR-containing building material and to remove any air bubbles. If the mould has been prepared on a vibrating table, the table may be vibrated to facilitate this agitation.

If the mould was prepared as described in Example 4a above, the lower layer of glass fibre matting which overlays the sides of the mould are folded in to make contact with the non-mould facing surface of the PUR-containing building material. A further layer of glass fibre matting is layered onto the non-mould facing surface of the PUR-containing building material and the folded in lower layer of glass fibre matting. The top surface of the glass fibre matting is covered with an approximately 2 mm layer of cementitious grout, typically of plastic density of about 2180 kg/m³ and cement content of between 400 and 500 kg/m³. The top surface of the cement grout is trowel finished to form the panel board's outer surface.

If the mould was prepared as described in Example 4b above, the lower GRC layer which was sprayed onto the extended mould pieces is folded in to make contact with the non-mould facing surface of the PUR-containing building material. A further layer of GRC

is sprayed and rolled onto the non-mould facing surface of the PUR-containing building material and the folded in lower GRC layer. The glass fibre is typically present at about 2% w/w cementitious grout. The cementitious grout typically is of plastic density of about 2180 kg/m³ and cement content of between 400 and 500 kg/m³. The top surface of the GRC layer is trowel finished to form the panel board's outer layer.

The formed panel boards are next left to cure. Curing may be facilitated by air curing for between 10 and 24 hours, preferably for about 12 hours, or by mist chamber curing for between 6 and 15 hours, preferably about 8 hours, until the board is suitable for striking from the mould. Care should be taken, in particular in the case of air curing, to take appropriate steps to prevent surface crazing and cracking caused by high ambient temperature drying.

When the formed panel board has been suitably cured it is struck from the mould. The finished panel board product is suitable for various building applications. A panel board made using PUR-containing building material of, for example, 0.85 final relative density is suitable for use in wall applications. A panel board made using PUR-containing building material of, for example, 0.97 final relative density is suitable for use in floor applications. By way of comparison, Aquapanel® has a final relative density of about 1.2.

6. Two-void building element constructed using PUR-containing panel boards

A two-void building element is constructed as shown in Figure 8. Three PUR-containing panel boards (65) are fixed together by suitable ties, for example Rapid Bar Ties (RMD Kwikform, Walsall, UK), so as to maintain a void between each board.

The outer "structural" void (70) is filled with self compacting concrete which may be reinforced concrete. The inner "insulation" void (75) is filled with a lightweight air entrained concrete which may also contain PUR. The wall resulting from such a construction has good thermal insulation properties with U-values of 0.45 W/m²K or better.

Industrial Applicability

Products and methods in accordance with the invention can be used in industry, in particular, though not exclusively, in the construction industry.

Claims

1. Concrete comprising PUR.
2. Concrete according to claim 1 comprising a binding agent, water and PUR.
3. Concrete according to claim 1 or 2 wherein the PUR is PUR foam.
4. Concrete according to claim 2 or 3 wherein the binding agent is cement.
5. Concrete according to claim 2 or 3 wherein the binding agent is gypsum.
6. Concrete according to any preceding claim wherein the concrete further comprises at least one bulking agent, waterproofing agent and/or flowing agent.
7. Concrete according to claim 6 wherein the bulking agent is limestone dust.
8. Concrete according to claim 6 wherein the bulking agent is silica sand.
9. Concrete according to any of claims 6 to 8 wherein the waterproofing agent is Hydrophobe.
10. Concrete according to any of claims 6 to 9 wherein the flowing agent is an air entrainer.
11. Concrete according to any of claims 6 to 9 wherein the flowing agent is a plasticiser.

12. Concrete according to any of claims 6 to 11 wherein the concrete comprises:

cement	240-450 kg/m ³
PUR	200-395 kg/m ³
Bulking agent	0-300 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	160-450 l/m ³

13. Concrete according to claim 12 wherein the concrete comprises:

Cement	375 kg/m ³
PUR	250kg/m ³
Bulking agent	250kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3 w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	200 l/m ³

14. Concrete according to claim 12 wherein the concrete comprises:

Cement	300kg/m ³
PUR	327kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06 w/w cement
Water	373 l/m ³

15. A construction element comprising concrete according to any of claims 1 to 14.
16. A method for preparing dried expanded PUR for use in the preparation of concrete, comprising:
 - a) soaking granulated PUR foam in water for a period of time sufficient to allow the PUR to expand;
 - b) separating the PUR from the water; and
 - c) drying the PUR.
17. A method according to claim 16, wherein the water is between pH 6 and pH 9.
18. A method according to claim 17, wherein the water is potable.
19. A method according to claim 16, 17 or 18 wherein the PUR is soaked in water for between ten minutes and two days.
20. A method according to claim 19 wherein the PUR is soaked in water for between 1.5 and 2.5 hours.
21. A method according to claim 20 wherein the PUR is soaked in water for about 2 hours.
22. A method according to any of claims 16 to 21 wherein the expanded PUR is dried by standing in air.
23. A method according to any of claims 16 to 21 wherein the expanded PUR is dried by forcing air past it.
24. A method according to claim 22 or 23 wherein the air is heated.

25. A method according to any of claims 16 to 24 wherein the expanded PUR is dried under pressure.
26. A method according to any of claims 16 to 25 further comprising a step to determine the water content of the dried PUR.
27. A method according to any of claims 16 to 26 wherein the PUR comprises recycled PUR foam.
28. A method according to claim 27 wherein the PUR is previously prepared from PUR foam chunks also containing impurities such as aluminium and/or other plastics material.
29. A method according to claim 28 wherein the PUR foam chunks are granulated and the impurities removed.
30. A method according to claim 29 wherein the PUR foam chunks are granulated using a granulator.
31. A method according to claim 29 wherein the PUR foam chunks are granulated using high pressure water jets.
32. A method according to claim 31 wherein the water jets are pressurised at between 10.35 and 48.25 MPa.
33. A method according to claim 32 wherein the water jets are pressurised at about 20.7 MPa.
34. A method according to claim 29 wherein the chunks are granulated by adding water and mixing in a high shear mixer.

35. A method according to claim 34 wherein the mixer operates at between 2000 and 6000 rpm.
36. A method according to claim 35 wherein the mixer operates at about 4000rpm.
37. A method according to any of claims 29 to 36 in which the impurities are removed by passing the granulated PUR foam through a mesh screen.
38. A method according to claim 37 in which the mesh screen is of between 75 μm and 4750 μm gauge.
39. A method according to claim 38 in which the mesh screen is of about 2360 μm gauge.
40. Dried expanded PUR obtainable by a method of any of claims 16 to 39.
41. A method for preparing a building material comprising mixing a binding agent and water with dried expanded PUR according to claim 40.
42. A method according to claim 41 wherein the binding agent is cement.
43. A method according to claim 41 wherein the binding agent is gypsum.
44. A method according to any of claims 41 to 43 wherein the method further comprises mixing at least one bulking agent, waterproofing agent and/or flowing agent with the other components of the mix.
45. A method according to claim 44 wherein the bulking agent is limestone dust.
46. A method according to claim 44 wherein the bulking agent is silica sand.

47. A method according to any of claims 44 to 46 wherein the waterproofing agent is Hydrophobe.
48. A method according to any of claims 44 to 47 wherein the flowing agent is an air entrainer.
49. A method according to any of claims 44 to 47 wherein the flowing agent is a plasticiser.
50. A method according to any of claims 44 to 49 wherein the components of the mix are present in the quantities:

Cement	240-450 kg/m ³
PUR	200-395 kg/m ³
Bulking agent	0-300 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	160-450 l/m ³

51. A method according to claim 50 wherein the components of the mix are present in the quantities:

Cement	375 kg/m ³
PUR	250 kg/m ³
Bulking agent	250 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	200 l/m ³

52. A method according to claim 50 wherein the components of the mix are present in the quantities:

Cement	300 kg/m ³
PUR	327 kg/m ³
Waterproofing agent (Hydrophobe)	0.1-0.3% w/w cement
Flowing agent (Airalon)	0.03-0.06% w/w cement
Water	373 l/m ³

53. A PUR building material obtainable by a method of any of claims 41 to 52.

54. A method of preparing a construction element comprising:

- preparing a mould sized to reflect the intended dimensions of the finished board;
- introducing a PUR building material according to claim 53 into the mould;
- curing the formed board; and
- separating the mould and the construction element.

55. A method according to claim 54 wherein preparing the mould comprises laying glass fibre matting in the base of the mould and covering the matting with a layer of cementitious grout.
56. A method according to claim 55 wherein the glass fibre matting is alkaline resistant.
57. A method according to claim 55 or 56 wherein the cementitious grout layer is 1-4 mm thick.
58. A method according to claim 57 wherein the cementitious grout layer is 1.5-2mm thick.
59. A method according to claim 57 or 58 wherein the cementitious grout layer is about 2mm thick.
60. A method according to any of claims 55 to 59 wherein the cementitious grout has a plastic density of about 2180 kg/m³.
61. A method according to any of claims 55 to 60 wherein the cementitious grout has a cement content of between 400 and 500 kg/m³.
62. A method according to any of claims 55 to 61 wherein the glass fibre matting extends outside the mould.
63. A method according to claim 62 wherein following the pouring of the PUR building material into the mould, the glass fibre matting which extends outside the mould is folded onto the non-mould facing surface of the PUR building material.
64. A method according to claim 54 wherein preparing the mould comprises spraying and rolling a layer of glass reinforced cement (GRC) into the base of the mould.

65. A method according to claim 64 wherein the sprayed and rolled layer of GRC is 1-4mm thick.
66. A method according to claim 65 wherein the sprayed and roller layer of GRC is 1.5-2mm thick.
67. A method according to claim 65 or 66 wherein the sprayed and rolled layer of GRC is about 2mm thick.
68. A method according to any of claims 64 to 67 wherein glass fibre is present in the GRC at about 2% w/w cementitious grout.
69. A method according to any of claims 64 to 68 wherein cementitious grout present in the GRC has a plastic density of about 2180 kg/m².
70. A method according to any of claims 64 to 69 wherein cementitious grout present in the GRC has a cement content of between 400 and 500 kg/m³.
71. A method according to any of claims 64 to 70 wherein the GRC is sprayed and rolled onto at least one extended mould piece and left for a period of time sufficient to allow the mix to set to form at least one GRC layer.
72. A method according to claim 71 wherein, following the pouring of the PUR building material into the mould, the or each GRC layer is folded onto the non-mould facing surface of the PUR building material.
73. A method according to any of claims 54 to 72 wherein, after the PUR building material has been poured into the mould, the mould is agitated to ensure uniform distribution within the mould of the PUR building material.

74. A method according to claim 73 wherein the mould is placed on a vibrating table to enable the agitation.
75. A method according to any of claims 54 to 74, further comprising:
- a) the laying of glass fibre matting over the non-mould facing surface of the poured PUR building material; and
 - b) the addition of a layer of cementitious grout over the top surface of the GRC matting.
76. A method according to claim 75, further comprising the trowel finishing of the cementitious grout layer.
77. A method according to claim 75 or 76 wherein the glass fibre matting is alkaline resistant.
78. A method according to any of claims 75 to 77 wherein the cementitious grout layer is 1-4 mm thick.
79. A method according to claim 78 wherein the cementitious grout layer is 1.5-2mm thick.
80. A method according to claim 78 or 79 wherein the cementitious grout layer is about 2mm thick.
81. A method according to any of claims 75 to 80 wherein the cementitious grout has a plastic density of about 2180 kg/m².
82. A method according to any of claims 75 to 81 wherein the cementitious grout has a cement content of between 400 and 500 kg/m³.
83. A method according to any of claims 54 to 74, further comprising the spraying and rolling of a layer of GRC onto the non-mould facing surface of the poured PUR

building material.

84. A method according to claim 83, further comprising the trowel finishing of the GRC layer.
85. A method according to claim 83 or 84 wherein the sprayed and rolled layer of GRC is 1-4mm thick.
86. A method according to claim 85 wherein the sprayed and rolled layer of GRC is 1.5-2mm thick.
87. A method according to claim 85 or 86 wherein the sprayed and rolled layer of GRC is about 2mm thick.
88. A method according to any of claims 83 to 87 wherein glass fibre is present in the GRC at about 2% w/w cementitious grout.
89. A method according to any of claims 83 to 88 wherein cementitious grout present in the GRC has a plastic density of about 2180 kg/m².
90. A method according to any of claims 83 to 89 wherein cementitious grout present in the GRC has a cement content of between 400 and 500 kg/m³.
91. A method according to any of claims 54 to 90 wherein the curing is air-curing for between 10 and 24 hours.
92. A method according to claim 91 wherein the curing is air-curing for about 12 hours.
93. A method according to any of claims 54 to 90 wherein the curing is accelerated by curing in a mist chamber for between 6 and 15 hours.

94. A method according to claim 93 wherein the curing is accelerated by curing in a mist chamber for about 8 hours.
95. A construction element for use in construction obtainable by a method of any of claims 54 to 94.
96. A building element comprising at least one construction element according to claim 15 or claim 95.
97. A building element according to claim 96 comprising three construction elements according to claim 15 or claim 95.
98. A building element according to claim 96 or 97 wherein the construction elements are fixed together so as to maintain a void between each construction element.
99. A building element according to claim 98 wherein at least one void is filled with self compacting concrete.
100. A building element according to claim 99 wherein the self compacting concrete is reinforced concrete.
101. A building element according to any of claims 98 to 100 wherein at least one void is filled with air entrained concrete.
102. A building element according to claim 101 wherein the air entrained concrete comprises PUR.

1 / 5

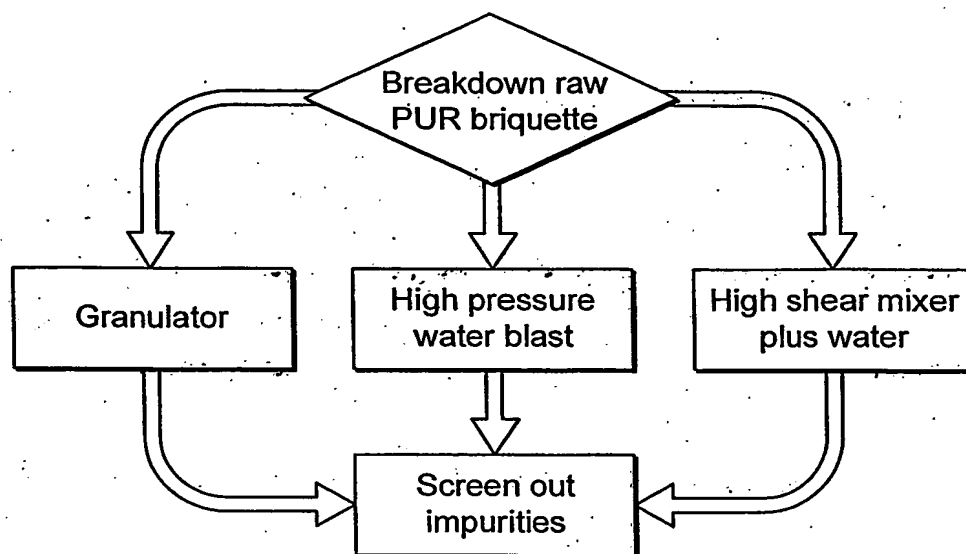


FIG. 1

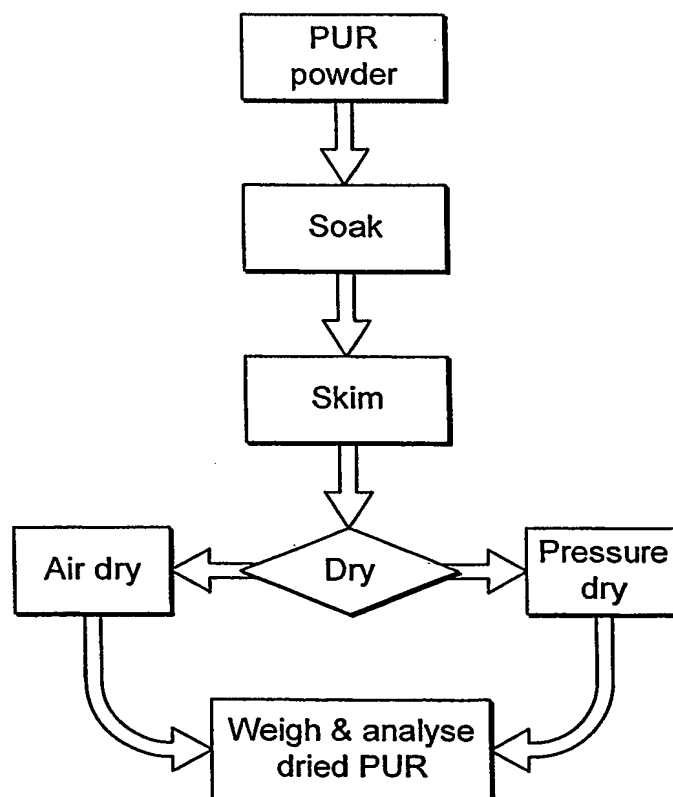


FIG. 2

2 / 5

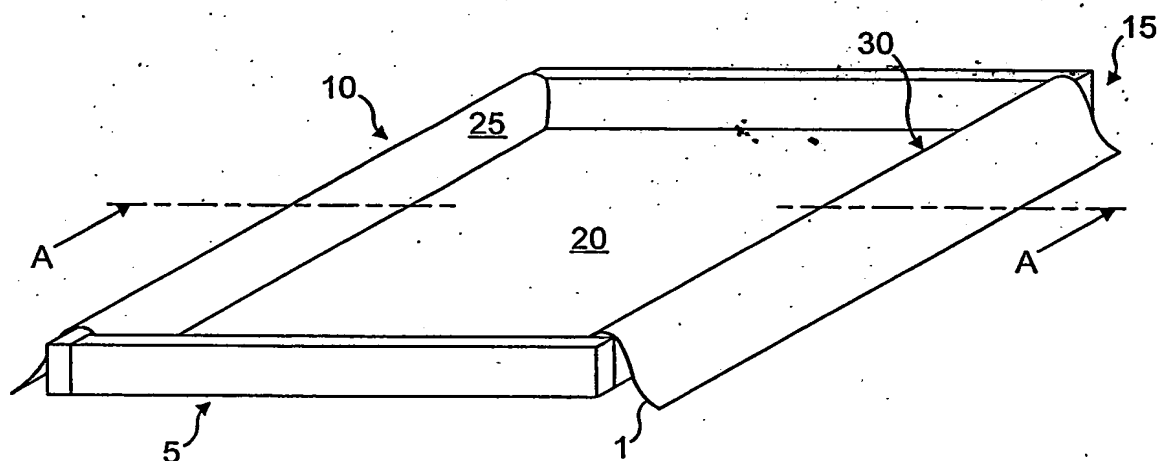


FIG. 3

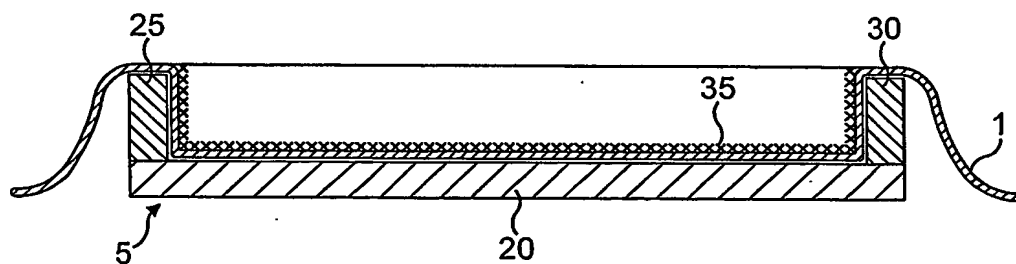


FIG. 4

3 / 5

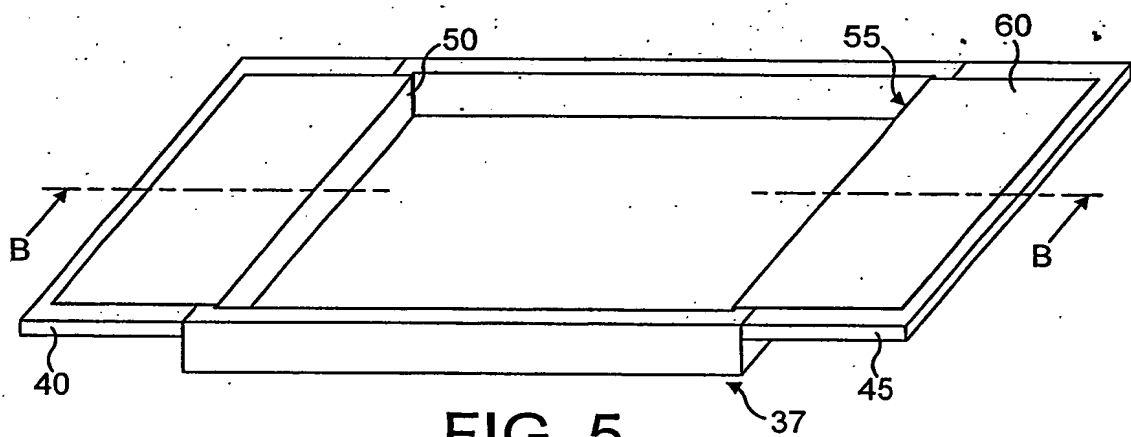


FIG. 5

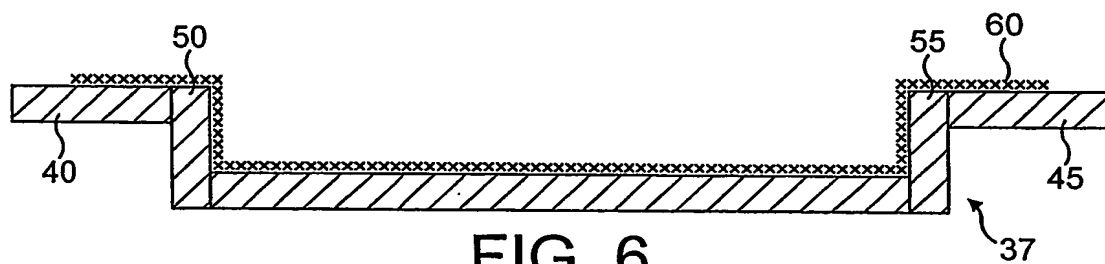


FIG. 6

4 / 5

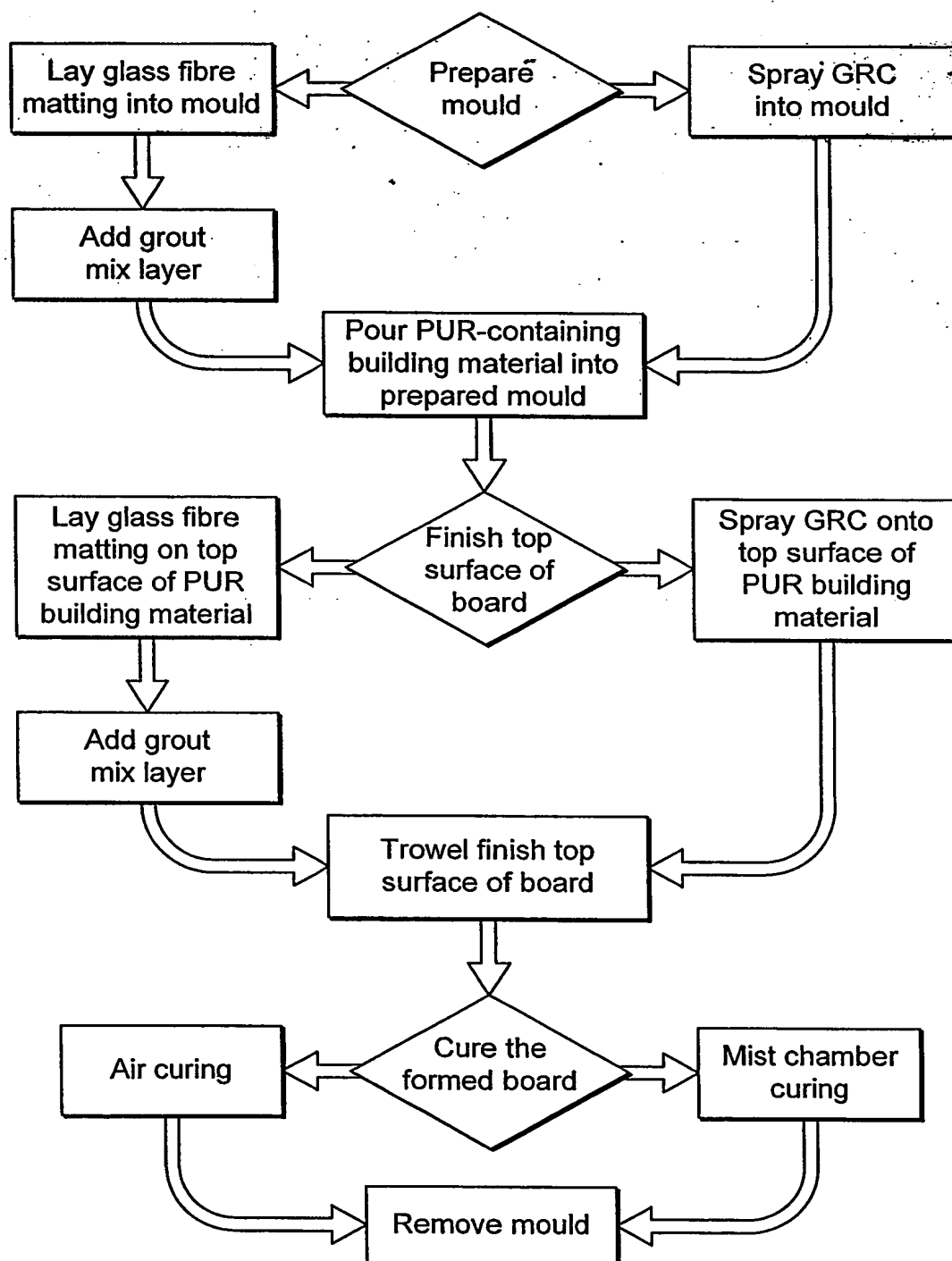


FIG. 7

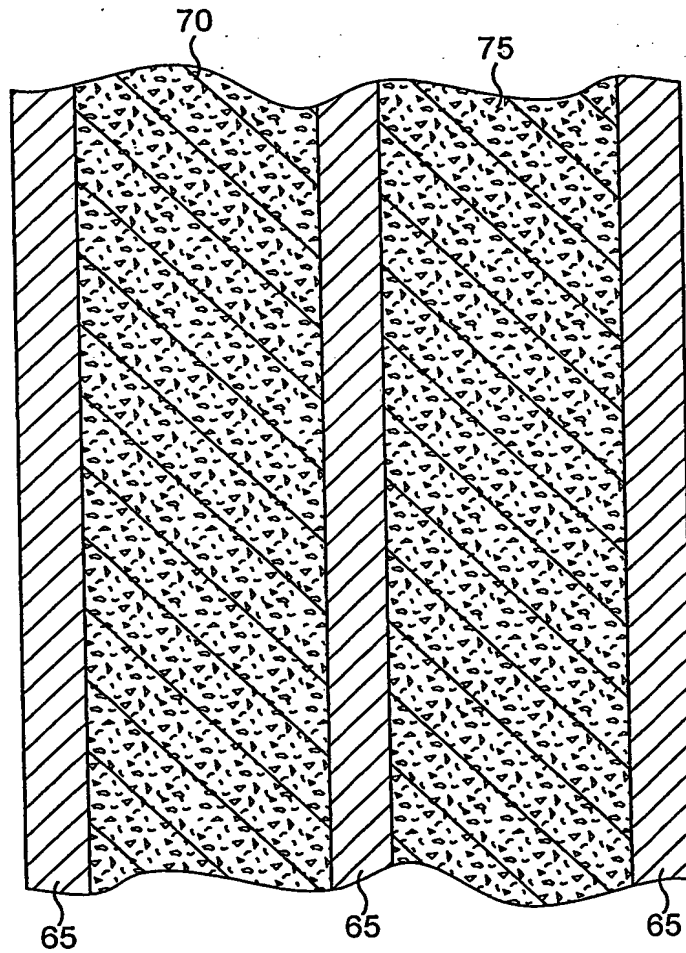


FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/03844

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C04B16/08 B28B23/00 C08J9/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C04B B28B C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 225 299 A (BASF) 17 March 1971 (1971-03-17) page 1, line 65-73 page 2, line 7-63	1-6, 8-12, 15
Y	---	7
X	GB 1 089 442 A (BUILDING RES HOLDING LTD) 1 November 1967 (1967-11-01) claims 1,8-11,16,17	1-4, 12-15, 54
Y	---	55, 56, 62, 63, 71, 72, 75, 95-98
Y	EP 0 164 300 A (TABAKOFF ALEXANDER DIPL ING ; INCEL ZEKI (DE)) 11 December 1985 (1985-12-11) claim 1	7

	-/-	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

12 February 2004

Date of mailing of the international search report

25/02/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Daeleman, P

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/03844

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 1 588 899 A (MASO THERM CORP) 29 April 1981 (1981-04-29) claim 1; figure 5	55, 56, 62, 63, 71, 72, 75, 95-98
X	DE 31 11 536 A (CARL HEINZ ING GRAD) 30 September 1982 (1982-09-30) claims 1, 2	1-4, 15
X	WO 97 31876 A (WETTER REGINA ; ALPHA BREVET SA (CH)) 4 September 1997 (1997-09-04) claim 1	1-3, 5, 15
X	WO 96 30315 A (BLOCKEN WILFRIED) 3 October 1996 (1996-10-03) claims 1, 2, 6, 7, 9	1-4, 10, 11, 15
X	DATABASE WPI Week 200279 Derwent Publications Ltd., London, GB; AN 2002-730407 XP002270116 & RU 2 188 176 C (GERASIMOV V V), 27 August 2002 (2002-08-27) abstract	1-3, 5-7, 15
X	US 5 422 051 A (SAWYERS JOHN P) 6 June 1995 (1995-06-06) column 3, line 59, 60; claims 1, 2	16-18, 22, 27-29, 40-42, 44, 46, 53
A	DE 42 33 600 C (HOELTER HEINZ) 3 March 1994 (1994-03-03) claim 1	16
A	EP 0 503 241 A (BASF AG) 16 September 1992 (1992-09-16) claim 1	1
A	US 5 350 554 A (MILLER ROBERT G) 27 September 1994 (1994-09-27)	
A	US 4 816 091 A (MILLER ROBERT G) 28 March 1989 (1989-03-28)	
A	DE 299 13 156 U (WEDI STEPHAN) 14 October 1999 (1999-10-14)	

-/--

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/03844

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p> DATABASE WPI Week 200042 Derwent Publications Ltd., London, GB; AN 2000-481562 XP002270117 & RU 2 140 886 C (LAPTEV I), 10 November 1999 (1999-11-10) abstract </p>	

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/GB 03/03844

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 1225299	A	17-03-1971	AT 285651 B BE 718640 A CH 488056 A DE 1658436 A1 FR 1575117 A NL 6810493 A ,B US 3732791 A	10-11-1970 27-01-1969 31-03-1970 15-04-1971 18-07-1969 29-01-1969 15-05-1973
GB 1089442	A	01-11-1967	AT 254025 B BE 662848 A	10-05-1967 17-08-1965
EP 0164300	A	11-12-1985	DE 3417077 A1 DE 3517005 A1 EP 0164300 A1	14-02-1985 13-11-1986 11-12-1985
GB 1588899	A	29-04-1981	US 4229497 A AU 3188777 A BR 7708678 A CA 1085182 A1 DE 2756820 A1 FR 2375405 A1 IL 53573 A IT 1091800 B JP 53092822 A ZA 7707251 A ES 466319 A1	21-10-1980 28-06-1979 15-08-1978 09-09-1980 29-06-1978 21-07-1978 16-09-1980 06-07-1985 15-08-1978 27-09-1978 01-10-1978
DE 3111536	A	30-09-1982	DE 3111536 A1	30-09-1982
WO 9731876	A	04-09-1997	WO 9731876 A1 AU 1759397 A DE 19780146 D2	04-09-1997 16-09-1997 25-11-1999
WO 9630315	A	03-10-1996	BE 1009260 A3 AT 174884 T AU 697758 B2 AU 5143596 A BG 62396 B1 BG 101899 A BR 9607765 A CA 2212962 A1 CN 1179141 A ,B CZ 9703003 A3 DE 59601052 D1 DK 815065 T3 WO 9630315 A1 EP 0815065 A1 ES 2128843 T3 GR 3029765 T3 HU 9800842 A2 JP 11505203 T NO 974391 A PL 322357 A1 RU 2158246 C2 TR 9700835 T1 US 5904763 A	07-01-1997 15-01-1999 15-10-1998 16-10-1996 29-10-1999 31-03-1998 30-11-1999 03-10-1996 15-04-1998 17-12-1997 04-02-1999 23-08-1999 03-10-1996 07-01-1998 16-05-1999 30-06-1999 28-08-1998 18-05-1999 23-09-1997 19-01-1998 27-10-2000 21-01-1998 18-05-1999
RU 2188176	C	27-08-2002	RU 2188176 C2	27-08-2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 03/03844

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5422051	A	06-06-1995	NONE	
DE 4233600	C	03-03-1994	DE 4233600 C1 DE 4323865 A1 DE 4325595 A1 EP 0591895 A2	03-03-1994 19-01-1995 02-02-1995 13-04-1994
EP 0503241	A	16-09-1992	DE 4104418 C1 AT 111012 T AU 644943 B2 AU 1090792 A CA 2061175 A1 DE 59200453 D1 EP 0503241 A1 ES 2059164 T3 JP 4318003 A US 5145878 A	14-05-1992 15-09-1994 23-12-1993 20-08-1992 15-08-1992 13-10-1994 16-09-1992 01-11-1994 09-11-1992 08-09-1992
US 5350554	A	27-09-1994	AU 1255792 A CA 2060060 A1 JP 6198618 A MX 9200213 A1 WO 9213645 A1	07-09-1992 02-08-1992 19-07-1994 01-08-1992 20-08-1992
US 4816091	A	28-03-1989	NONE	
DE 29913156	U	14-10-1999	DE 29913156 U1 DE 20012738 U1 EP 1072397 A2	14-10-1999 07-12-2000 31-01-2001
RU 2140886	C	10-11-1999	RU 2140886 C1	10-11-1999

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☒ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.